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ABSTRACT

This conference presentation analyzes the present and anticipated future employment situation for mathematicians, scientists, and engineers in the Federal Republic of Germany. On the whole, it is determined that supply and demand for mathematicians, scientists, and engineers will be generally balanced, though there may be imbalances in individual occupational sectors or local regions. In order to maintain its high standard of living and compete successfully in the world market, West Germany has developed measures to encourage outstanding achievements of its highly talented citizens. These measures include federal talent competitions, school working groups, summer courses, inservice training for teachers, direct contact with university professors, establishment of graduate colleges, and financial aid and academic guidance from foundations. Government-sponsored research focuses on development of a model to identify outstanding talent, determining reasons for the low proportion of women in these fields, and examining the role of leisure time in developing talent. (JDD)

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THE FEDERAL REPUBLIC OF GERMANY'S RESPONSE TO THE NEED FOR TALENT IN MATHEMATICS, SCIENCE AND TECHNOLOGY

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Two preliminary remarks:

- In the Federal Republic of Germany, too, mathematicians and scientists are trained solely at universities. In contrast, there are many possibilities for training technicians even below the university level, particularly if the aim is to provide training oriented to practical requirement. This paper merely refers to engineers who have graduated from a university.

- Secondly, there is a wide variety of employment possibilities for mathematicians, scientists and engineers and the requirements of the employment system are quite different. This is why a comprehensive reply might, to a certain extent, be inaccurate.

1. Introduction

Germany's response to the need for talent in specific scientific fields can be understood only against the background of the present and probable future requirements of the German employment system and--in this context--major basic political deliberations. For this reason, these requirements and basic deliberations are discussed first.

2. The Present and Anticipated Future Employment Situation: The Requirements Set by the Employment System

2.1 At present, an annual average of approximately 27 million persons are gainfully employed in the Federal Republic of Germany. Of this number, approximately 580,000 (approximately 2 percent) are mathematicians, scientists and engineers. In 1986 approximately 43,000 persons graduated in these subjects from universities. That is approximately 8 percent of the number of gainfully employed persons with thse training qualifications. Thus, the number of persons entering these professions each year is far higher than the number of those with corresponding qualifications who are leaving the professions.

In the same year, approximately 25,000 persons were registered as being unemployed - that is approximately 4.4 percent of the number of gainfully employed persons with the same training qualifications. *At the moment,* it would appear that the *situation on the labor market* for this group is relatively *balanced and favorable.*

2.2 The Anticipated Need

The experience gained in the Federal Republic of Germany in the seventies on the basis of isolated prognoses of the employment market for specific professions led to the conclusion that it is not possible to make reliable prognoses. There are too many imponderable factors with regard to the preliminary assessment of, for example, economic growth or the effects of technological changes on economic, production and occupational structures and

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therefore also on the qualification requirements of the employment system. The solution today seems to be the application of consistent model calculations by which an attempt will be made to estimate general development trends and thus also to identify in good time potential imbalances between supply and demand with regard to specific qualifications.

In the Federal Republic of Germany, there is a comprehensive model calculation of this nature which provides an advance estimate of manpower requirements until the year 2000 with regard to numbers, occupations and qualifications, giving particular consideration to the technological development.

- The application of information technology is expected to result in a major *change* in the *structure of branches* of the economy: there will be a considerable expansion in the service sector, whereas the sectors of agriculture and production will decline.

- Moreover, the major changes will take place in the *structures of production and organization.* Thus executives in particular will be required to have basic technical knowledge, the ability to apply technology economically and handle comprehensive planning strategies expertly.

- As far as *occupational structures* are concerned, a rapid and relatively sharp increase is expected in executive and management tasks.

In view of these anticipated changes, it is expected that, until the year 2000, the Federal Republic of Germany will experience an increase in the proportion of positions for university graduates from approximately 8.5% to 13 to 15%. There will certainly be a disproportionate increase in the sector of information technology and related occupations, that is, precisely in that group of preparatory training programs discussed here. **A total increase** from 560,000 persons in 1985 to approximately 1 million persons in the year 2000 is expected.

2.3 New Entrants to These Professions

The extent to which this anticipated need will be covered can be forecast with considerable certainty. Most of those who will be gainfully employed in the year 2000 are already trained or are presently undergoing training in relevant study courses. The forecast gains reliability from the fact that, as a consequence of the low proportion of female students, an employment rate of virtually 100 percent can be assumed.

During the past few years, the number of these recruits has increased considerably in the case of mathematicians, scientists and engineers, namely, by 15 percent from 1975 until 1985. It is to be expected that this increase will continue, probably by about 40 percent from 1975 until 1992.

This *favorable development will continue* since it is common knowledge that there are excellent employment opportunities for graduates from these

study courses and experience has shown that would-be students are quick to enroll for such studies.

2.4 **Conclusion**

On the whole, on the basis of a comprehensive examination of the situation until the year 2000 with regard to the employment of university graduates in the Federal Republic of Germany, it can be assumed that supply and demand will be generally balanced.

In principle, this applies also to mathematicians, scientists and engineers. However, with regard to this group, it must be admitted that despite of the general balance I have just mentioned there may be imbalances in individual occupational sectors or local regions. In order to prevent a shortage of personnel in information technology and related professions--which would be extremely damaging to the economic development--the Federal Government has advocated the development of such study places and unrestricted access to them. In view of these measures and because study applicants are aware of the excellent employment and career opportunities open to them, it is assumed that in this field, too, there will be a *quantitatively adequate number of new graduates.*

In view of the excellent training programs and stringent examination requirements under our higher education system there is also no reason to doubt that, on average, new graduates *will be qualitatively adequate,* too.

3. **Fostering the Highly Talented**

3.1 The question is whether we can be satisfied with this. An international comparison reveals that the standard of living in the Federal Republic of Germany is extremely high. This also applies to those members of the German population who depend on transfer income which have to be provided by heavy taxation and social contributions of the respective groups of gainfully employed persons. In 1986, its share of the gross national product amounted to 39.3 percent. In the USA it amounted to 28.9 percent--a figure which does not even take into account the effects of the 1986 U.S. tax reform.

Germany has to work for this standard of living, to quite a considerable extent, in hard competition on the world market. Its export quota amounts to more than 30 percent--in comparison, that of the USA is approximately 7%. Competition is becoming increasingly tough. The number of highly efficient industrialized countries has increased and, therefore, also the number of competitors.

In order merely to maintain our standard of living, a constant stream of more intelligent products, production techniques, and services must be offered. In the long run, this will not be effected on the strength of average scientific and technical performance. Outstanding achievements--particularly also in the field of basic research--are required. It must, therefore, be the

task and goal to attain such achievements--or, put more precisely--to demand of the appropriately qualified citizens to devote their expertise to this end.

3.2 The resulting challenge and promotion of highly gifted students--particularly in the fields of mathematics, science and technology has been recognized since the early eighties in the Federal Republic of Germany as a major task for education. On the one hand, this particular point in time can be explained by the fact that throughout Europe the awareness of the importance of this issue had increased. On the other hand, the political majority in the Federal Republic of Germany changed at that time: social democratic policy in the field of education had a very strong orientation to the concepts of equality and special care and assistance of the disadvantaged. In contrast, the policy pursued by the Christian democratic-liberal coalition aims to identify and recognize different talents and to encourage these appropriately by offering differentiated education programs. The Government does not believe that highly talented students are able to make their way alone unaided. This goes to show that active promotion of highly talented students is called for.

To rule out any misunderstanding from the start: The encouragement of outstanding achievements to the advantage of society--including economic benefits--is just one of the aims of Federal Government's promotion of highly gifted students. The Government gives priority to the individual, human aspect being convinced that the full development of a particular talent is part of a fulfilled life.

4. Measures for Promoting the Highly Talented

In illustrating the promotion measures, those measures can be disregarded which concern pupils who are particularly talented in the fields of art and sports or who show particular psychomotor and social skills. The measures addressed to students highly talented in these fields toughly differ from those addressed to academically gifted. In contrast, the measures addressed to the academically talented--particularly in the higher education sector--will hardly differ whether they are arranged for mathematically, scientifically and technically or for those highly gifted in the field of humanities. Therefore, it is allowed to describe the measures addressed to the academically talented at all.

4.1 One of the most pressing tasks in the Federal Republic is that of *arousing and increasing the awareness* of the public--in particular of parents, teachers and older pupils--of the justification and necessity of special promotion for highly gifted students. The services of education policy makers and experts in the fields of pedagogics, psychology, medicine, economics and administration must be won for scientific research and practical work.

4.2 The Individual Promotion Measures

For the adolescents aged between 16 and 19 years who are preparing themselves at high school (in Germany called Gymnasium) for access to higher education or who are already undergoing vocational training there are several

extremely demanding *federal competitions* in the fields of mathematics, chemistry, physics, information science and also in foreign languages and history.

These talent competitions are an invitation to young people to test and develop their particular aptitudes and skills and thus enhance the whole of their personality.

The most important young researcher's competition in the Federal Republic of Germany is "Jugend forscht" ("Young researchers"). In this competition, participants do not compete against each other in the fulfilment of particular tasks; on the contrary, they submit to a jury scientific and technical projects which they have undertaken themselves of their own accord.

The competitions are usually at three levels: first at the regional level, then at the Lander level, and finally at the federal level. In the year 1987 approximately 90,000 young persons participated in these competitions. The national winners are admitted to the highly esteemed German National Scholarship Foundation which gives them intensive guidance and assistance, also financial assistance, during their studies. The national winners in the Federal Republic of Germany are sent to participate in the international competitions ("Olympics").

At the school level a growing number of additional *working groups* are being set up with increasing success--as scientific evaluation studies reveal. A prerequisite for participation in these working groups is high performance, motivation and ability.

In the USA, we learned the role and usefulness of special *summer courses* for highly talented students. We have been informed by participants in the Federal German competitions that these highly gifted adolescents miss the exchange of views and experience with young people of similar interests and a high level of knowledge. The Federal Ministry of Education and Science is therefore engaging in experiments concerning the organization of such summer camps.

A further important activity takes place in the field of *inservice training for teachers.* They have not only to be convinced of the necessity of such initiatives already mentioned. They must also be enabled to identify special talent as early as possible and provide professional as well as sensitive support. This includes the provision of specialized knowledge and special teaching materials.

4.3 In the *higher education sector,* by tradition the most intensive form of promotion is provided by the student's direct contact with professors and their assistants--a contact which increases as the study course progresses and as the student acquires greater skills and knowledge. The admission of highly talented students to special study programs and their direct involvement in research activities are certainly good means to create excellence both in the Federal Republic of Germany and in the USA.

In order to explain *specific promotion measures* with regard to the structure of academic institutions and teaching, a brief reference to the differences between the German and U.S. higher education systems must be made. There is no order of priority among the universities.

Then, uniform coherent study courses are instituted in the different disciplines which lead to final examinations held by the university or the state. In principle, each holder of the Abitur certificate is entitled to enroll for these uniform study courses and for all those who are interested in the respective specialized field it constitutes the actual study phase.
Efforts to introduce increased promotion of highly talented students start by criticism of the basic structure already described of German higher education institutions and with the desire to change them:

- Increased *qualitative competition between the faculties* at different universities; the amendment in 1985 to the Framework Act for Higher Education created the initial prerequisites to this end;

- Increased *participation by the faculties* with regard *to the admission of students* to higher education studies on the basis of talent and aptitude; a start was made in this respect in 1986 in the field of medicine when the faculties were involved in the selection of 15 percent of the overall number of freshmen;

- The provision of *specific study programs* for particularly talented students; the amendment to the Framework Act for Higher Education just mentioned made it possible to establish such study programs.

Moreover, the "Science Council"--a highly esteemed body advising the Federal and Lavender governments among other things on the development of higher education institutions--has recommended that *graduate colleges* be set up. On completion of generally accessible study courses, these colleges are to promote particularly well qualified young scientists working in research groups devoted to specific topics over a period of two to three years.

Even in the sector of the extremely conventional higher education institutions, there is a trend towards the provision of increased promotion for highly talented students.

For the sake of completeness, there are at least eight *foundations* which devote their efforts to *talent promotion in the higher education sector.* The largest and most well-known of these institutions is the German National Scholarship Foundation. Private foundations have been set up by the Protestant and Roman Catholic Churches, the political parties, and trade unions. Their task, in addition to giving financial aid, is to provide a certain amount of academic guidance. In particular, however, their intention is to prepare outstandingly qualified students for responsible participation in cultural, political and social tasks in society.

5. Research

Research on the talent has been a central concern in the fields of psychology and pedagogics since the beginning of this century. On the other hand, it is only recently that the phenomenon of outstanding talent has attracted particular scientific attention. It is now important that there is the opportunity to transfer to Germany's basic cultural situation and basic policy principles the knowledge and techniques elaborated in other countries for the identification and promotion of specially gifted students.

The individual research projects introduced by the Federal Ministry of Education and Science concern topics ranging from studies on the various ways in which special talent is manifested and the structure of intelligence, the diagnosis of outstanding talent with the aid of new procedures, the role played by aptitudes and environmental influences and the course of development of outstanding talent to the testing of suitable timing and methods of promotion. Above and beyond this, activities have been promoted which concern the connection between outstanding talent and motivation structure.

At the moment, there are *three problem complexes:*

First, with regard to a specific type of talent (in concrete terms: technical creativity) we intend to find ways for identification, consulting, promotion both within and outside schools including distance study programs, and the training of third parties for the provision of promotion. The aim is to provide for this important group of highly talented students guidelines which are as complete and intelligible as possible. Because of this, *a model is to be created for* similar *guidelines* for other types of outstanding talent. Of course, the guidelines will be partly different--especially with regard to the identification of exceptional talent. It is important that a complete concept can be presented for the treatment of specially talented students. Professor K. Heller, professor of psychology at the University of Munich, has taken on this task. He is cooperating with the Psychological Institute of the Academic Sinica in Bejing.

The second problem, which is still important even in the wake of the general political discussion on equality for women, is the unusually low proportion of women among mathematicians, scientists, and engineers in general and, in particular, in the numbers of those who demonstrate special achievements. It is obviously noticeable from the small number of female participants in our competitions in the fields of mathematics and science. The Federal Government wants to know the reasons why: Is it due to aptitude, traditional role-playing or repression during special phases of development? It wants to know whether this can be changed and how to do it. The Federal Government requested the foundation, "Young Researchers," and Professor Wieczerkowski from the University of Hamburg to investigate these correlations. This problem complex seems to be of international importance and, therefore, a challenge to all.

A third research topic, *leisure time*--the time which the individual is free to plan as he/she pleases--offers particular opportunities for developing talents and skills, creativity, and the capacity for innovation. By its very nature, it is precisely leisure time which gives special chances to the highly talented and is, therefore, of major importance for the development of their gifts. Until now, no studies have been devoted to the ways in which highly talented persons use their leisure time. Therefore, an investigation of the leisure time pursuits and of the relevant general conditions is being undertaken. The goal is to produce recommendations for young people to use their leisure time in order to optimize their aptitudes. An international group of experts under the chairpersonship of Professor Heller of the University of Munich has now started this research. The Federal Government welcomes this initiative and gives strong support to this project.